PRESENT STATUS OF NATURAL RESOURCE

Description

The park lies on the boundary of two major biogeographical provinces. This boundary is particularly noticeable in the marine environment. The westernmost islands of San Miguel and Santa Rosa are bathed by cold northern waters of the boreal Oregonian province carried south by the California current. Waters surrounding the southeastern islands of Santa Barbara and Anacapa come from the south along the mainland coast and support a warm temperate biota known as the Californian province. Santa Cruz Island sits directly astride this boundary, where plants and animals from both provinces mingle and create a unique assemblage of species capable of adapting to the variable conditions of the transition zone. Park waters harbor biota representative of more than 1000 miles of the North American coast from Enseñada, Mexico, to San Francisco, California.

Oceanography

Prevailing winds and the bathymetry of adjacent basins also greatly influence biological communities in the park. Winter storms bring rain and buffet the islands' northern shores, whereas biota of the southern coasts reflect a drier, more sheltered environment. The confluence of major oceanic currents and the shape of the continental shelf create a rare phenomenon of persistent upwelling near the park. Nutrient-rich water wells up from the deep sea near Point Conception, on the mainland coast to the north, and produces exceptionally productive food webs in the waters around San Miguel and Santa Rosa islands.

The waters of Channel Islands National Park harbor an ecologically diverse array of species assemblages. The western park islands, San Miguel and Santa Rosa, are bathed by northern waters carried south by the California Current and therefore reflect the biological assemblages of the Oregonian province. Waters around the eastern park islands of Anacapa and Santa Barbara come from the south along the mainland coast and support the warm temperate biota characteristic of the Californian province. Around Santa Cruz Island, at the boundary of these two provinces, there is a broad transition zone where plants and animals from both provinces mingle and create a special assemblage of species that are capable of adapting to the unique and variable conditions of the transition zone. In addition to this unique transition zone, park waters harbor species assemblages that are representative of nearly 1,000 miles of the California coast from San Diego to San Francisco.

Prevailing winds and the bathymetry of adjacent basins also greatly influence marine communities in the park. Strong north winds buffet the north sides of the islands, while the biota of the southern coasts reflect their more sheltered positions. Upwelling nutrients from basins, greater than 1-mile deep, to the south and west of the park produce exceptionally productive food webs and temperature regimes that differ significantly from the shallow northern sides of the islands. The richness and diversity of the marine communities are reflected by an abundance and diversity of marine mammals and seabirds.

Geology

The geological story of this region is complex. The islands themselves can be separated into the northern group of four islands (all within the park) and the southern group of four islands (of this group, only Santa Barbara Island is within the park). The northern islands are thought to be a seaward extension of the Santa Monica Mountains (although never connected in a land bridge), developed from the end of the Miocene through the processes of faulting and uplift. Though these islands were never linked to the mainland by a land bridge, they are thought to have been joined with each other as one large island called "Santarosae" during the Pleistocene, when the sea level was at its lowest. The southern islands are thought never to have been linked to each other or to the mainland.

The geologic composition of the islands dates from the Mesozoic Era 65-210 million years before the current interglacial episode of the Pleistocene Epoch. Throughout this time the island terrains have rafted northward, rotated clockwise, submerged and elevated through combinations of tectonic compression and fluctuating (eustatic) sea levels resulting from the expanding and retreating polar ice caps of the ice age (Howell et al. 1987). Documentation regarding the amount of time that terrestrial conditions have existed since the last full emergence from submarine environments is largely inferential (Vedder and Howell 1980). However, electrophoretic studies of the Channel Islands slender salamander (*Batrachoseps pacificus ssp. pacificus*) indicate that the insular populations differ enough from the mainland populations to suggest a separation of at least 4 million years (Schoenherr 1992). During the Middle Pleistocene

(1 million years ago), only the highest elevations of Santa Catalina, Santa Cruz, and Santa Rosa were not submerged (Vedder and Howell 1980). During the last full glacial episode (20,000 years ago years ago) when sea level was approximately 130 m (275 ft.) lower than today, the four northern islands were connected, forming one super island called Santarosae, which was at that time separated from the mainland by a distance of only 6 km (3.6 mi.).

The islands represent examples of some of the most extensive marine terraces in the world and contain many sea caves, rugged shorelines, sandy beaches, mountain peaks, and valleys. Eolian land forms with active dunes are represented. Sand castings of trunks, branches and roots from an ancient forest, known as caliche, are also present. Fossils representing now extinct populations, particularly pygmy mammoth, abound in several localities.

These unusual deposits are among the most interesting of the geologic features found on the islands.

Paleontological Resources

The Pleistocene fauna of the Channel Islands is unique in several respects. First, it contains several extinct species, including pygmy mammoth, flightless goose, two species of giant mouse, and a vampire bat. It also contains the best representation of a Pleistocene marine avifauna on the Pacific coast. Most importantly, the fossil record provides evidence of the evolution of the island fauna and the effects on this fauna of human colonization.

The ecosystems and species compositions on the islands, as recently as 10,000-20,000 years ago, were substantially different from those found at the time of early European exploration. Regional changes in native species composition have resulted from major plant migrations accompanying climatic fluctuations. Pygmy mammoths were present on the northern islands during the last full glacial episode (13,000 to 10,000 years ago, Orr 1967). Also during this episode, coastal coniferous forests, including coastal Sequoia forests, occurred on the mainland (Stock and Harris 1992). (Relict northern plant associations currently found on the islands lie approximately 200 km [120 mi.] south of the southernmost extensions of their more widespread mainland counterparts [Raven 1967]). A climatic period considerably warmer and drier than that of today began on the islands approximately 7,000 years ago (Axelrod 1967); pygmy mammoths probably became extinct prior to this period (Orr 1967). This extreme climate, termed the Xerothermic, contributed desert species to the regional biological diversity (Axelrod 1967). Subsequent ecological stabilization of vegetation boundaries and species composition developed in the absence of grazing pressures on the islands.

The best studied aspect of island paleontology is the numerous fossil bones of the pygmy mammoth, *Mammuthus exilis*, a unique species found on the northern Channel Islands, most commonly on Santa Rosa Island. This species descended from full sized ancestors who swam the Santa Barbara Channel to the islands during the Pleistocene and became isolated on the islands. Dying off at about the end of the Pleistocene (12,000 years ago), these animals are represented by fossils which are often exposed in sands, silts, and gravels of Pleistocene age anywhere on the island. Most specimens have been found in the sediments comprising the coastal terraces of the island. Due to the numerous questions about many aspects of this species evolution and development, any fossil may potentially be of crucial importance in answering important research questions. Other fossil localities containing smaller terrestrial species of Pleistocene age and invertebrate fossils embedded within the Miocene strata of the island remain unstudied. Today, bones are often exposed by erosion, and unless collected properly and promptly, they may be scattered and lost due to weather and the actions of large mammals on the island.

Soils

Current knowledge of park soils is limited to a study by Johnson (1979), who conducted a cursory investigation of soils, geology and erosion problems on Santa Barbara, Anacapa and San Miguel Islands. Santa Rosa and Santa Cruz Islands were not surveyed. Soils generally range from fine sandy loams to clay loam, and are easily erodible. Surveys of cyanobacterial soil crusts on the Channel Islands show that these crusts should cover the soil surface in most of the vegetation types (Belnap, 1994b; pers. obs.). However, these crusts did not evolve under grazing pressure (Mack and Thompson, 1982), and are impacted by soil surface disturbance, including grazing (Harper and Marble, 1988; Jeffries and Klopatek, 1987), people and off-road vehicles (Cole, 1990; Belnap et al., 1994; Belnap, in press). Crusts on the Channel Islands are especially susceptible to impacts from hooved animals (Belnap, pers. obs.). These crusts are important for increased soil stability, water infiltration, and fertility of soils (Harper and Marble, 1988; Johansen 1993; Metting 1993; Belnap and Gardner, 1993; Evans and Ehlringer, 1994; Belnap, 1994a; Belnap et al. 1994). Absence of these crusts can lead to increased erosion, with resultant loss of organic matter, fine soil particles, nutrients and microbial populations in soils (Schimel et al. 1985).

Normal nutrient cycles can also be disrupted by soil surface disturbance. Experiments have demonstrated that all types of surface disturbance tested dramatically decreased nitrogenase activity in these crusts (Belnap et al., 1993; Belnap, in press). Plants growing in crusted areas have significantly more nitrogen in their tissue than plants growing in trampled areas without crusts (Belnap and Harper, 1995; Harper and Pendleton, 1993). Cyanobacterial-lichen soil crusts are also an important source of fixed carbon for sparsely vegetated areas (Beymer and Klopatek, 1991). In addition, soil disturbance can alter soil food webs and thereby affect nutrient availability in these systems (Ingham et al., 1989). Disruptions of soil food webs can reverberate throughout the ecosystem, affecting macro-floral and faunal components (Hendrix et al., 1992; Coleman et al. 1992). Recovery is extremely slow, taking 100-150 years for soils to dilate, and over 250 years for crusts to fully recover (Webb and Wilshire, 1980; Belnap, 1993).

Plant community composition and architecture can also be affected by soil surface disturbance. Changes in these critical habitat components has been shown to affect invertebrate and vertebrate populations (MacMahon 1987).

Vegetation communities

The main habitat types on the islands include coastal dune, coastal bluff, grasslands, coastal sage scrub, chaparral, island oak woodlands, mixed hardwood woodlands, conifer stands, riparian areas and wetland communities. Various subdivisions of these types have been described by Dunkle (1950), Philbrick and Haller (1977), Minnich (1980), and Clark et al. (1990). The floristics of the islands are composed of elements that have a variety of origins. Relict species (wide ranging in the paleobotanic fossil record) such as the endemic island ironwoods (*Lyonothamnus floribundus*), and species such as the Torrey pine (*Pinus torreyana*), which exhibit disjunct distributions from their mainland counterparts, occur in canyons and slopes that provide higher moisture than the surrounding areas. Unique insular endemics, including all of the listed species, have been discussed by Raven (1967), Philbrick (1980), and Wallace (1985).

Coastal beach and associated dune habitats occur in the windiest sandy locations on all the northern islands but Anacapa, and coastal bluffs occur on all the islands. These coastal habitats appear to be relatively undisturbed compared to their counterparts on the mainland, where development and recreation have largely eliminated them. Because of its steep slope and general inaccessibility, coastal bluff habitat has provided a refugium from the habitat elimination that has accompanied alien herbivore grazing on the islands (Minnich 1980; Halvorson et al. 1992).

Coastal sage scrub is composed of soft-leaved, soft-stemmed plants that are palatable to browsers and grazers. The original coastal sage scrub habitat was reduced by overgrazing to the extent that it persists only in locations that are inaccessible to grazing and browsing animals, as in patches of cactus and on bluffs and canyon walls (Minnich 1980; Hobbs 1983). Coastal sage scrub has recovered well on the portion of SCI where sheep were removed nearly twenty years ago.

Before the introduction of alien animals (both livestock and wildlife), the upland habitat was largely shrubland; now, many of its representative species are found only on bluff sites (D'Antonio et al. 1992). The grasslands have greatly expanded at the expense of most other habitat types, and are largely composed of non-native annual species (Hobbs 1983; Cole 1994). In contrast, historical photographs reveal woody vegetation that has been lost from the islands during the last 100 years (Hobbs 1980; Minnich 1980). On Anacapa and San Miguel Islands, where grazing has been removed for over 50 years, the coastal sage scrub habitat has increased in extent (Johnson 1980). Here, the uncontrolled effects of grazing which eliminated or drastically reduced shrubland and artificially increased grasslands are diminishing.

The pre-grazing importance of cactus in the island communities may never be known, because overgrazing results in the spread of cactus to areas that have been denuded by livestock. Overgrazing on Santa Cruz Island greatly facilitated the spread of cactus to the point that over 40% of the “rangeland” was rendered useless for grazing (Hochberg et al. 1980a). On both Santa Cruz and Santa Rosa islands, a biological control agent, cocchineal scale, was employed to suppress cactus and improve grazing opportunities, have dramatically reduced cactus populations (Hochberg et al. 1980a). The scale insect persists on the islands.

The physical condition of the remnant chaparral habitats has been modified by grazing which has altered understory species composition, and by browsing that has pruned shrubs into unnatural, arborescent or tree-like shapes. Browsing by deer and elk on Santa Rosa Island and sheep on Santa Cruz Island has created an open “skeleton” community, reticulated by game trails, resulting in herbivore access to nearly 100% of the habitat (Hochberg et al. 1980a; Tim Thomas, USFWS, pers. obs. 1993). In contrast, historic reports on the conditions of the islands relate that the brushlands were impenetrable (Hochberg et al. 1980a).

Island woodlands are dominated by unique endemic tree species and have been affected heavily by grazing, browsing, and rooting animals seeking summer shelter and food (Clark et al. 1990; Halvorson 1993). Bishop pine forests areas that are protected from grazing have well-developed foliar cover and pine reproduction (Hobbs 1978). In contrast, Clark et al. (1990) report that on Santa

Rosa Island, Bishop pine forests subjected to grazing lack the protective nutrient layer of ground litter and exhibit no reproduction.

Riparian habitats are one of the most significant vegetation communities on the islands and throughout the arid west. The island riparian habitats have been heavily modified physically and structurally, and in some areas have been eliminated completely (Hochberg et al. 1980a; Minnich 1980). Normally, a canyon with year-round water will have well-developed riparian vegetation including willows (*Salix* spp.), sycamores (*Platanus racemosa*), cottonwoods (*Populus* spp.) and oaks (*Quercus* spp.). This vegetation would typically support a rich diversity of organisms, especially neo-tropical migratory bird species (Paul Collins, pers. comm. 1994). There are sufficient examples of remnant riparian communities on the islands to demonstrate that this condition occurred prior to the ranching era. However, years of livestock over-utilization have considerably reduced this resource-rich habitat.

Researchers Cole and Liu (1994) analyzed a 5 meter / 5,200 year-old soil core collected in 1989 from a small estuary at the eastern end of the island. The core showed an increase in sedimentation rates from an average of 0.7 mm per year for the 5,000-year period prior to settlement (or the "background "erosion rates) to an average of 13.4 mm per year for the post settlement period. Sedimentation rates peaked from 1874 to 1920, at 23.0 mm per year.

Woodlands are an ecologically important though uncommon component of the Santa Rosa Island vegetation. Altogether, upland and riparian woodlands account for less than 1% of the island's cover. Upland woodlands are dominated by pines, oaks, or other mixed hardwoods (i.e. oak, cherry, and ironwood). Eight native and three alien tree species occur on the island. Two of the native species, Island oak (*Quercus tomentella*), and ironwood (*Lyonothamnus floribundus* ssp. *asplenifolius*), are found nowhere else in the world other than on the Channel Islands. Torrey pine (*Pinus torreyana* ssp. *insularis*) occurs only on Santa Rosa and a portion of the mainland near San Diego.

On Santa Rosa Island, the alien trees, eucalyptus (*Eucalyptus globulus*), Monterey pine (*Pinus radiata*), and tamarisk (*Tamarix aphylla*), are currently confined to the ranch headquarters area. Native trees occur in discrete groves rather than being widely distributed across the landscape. There are two stands of Torrey pine and nine known groves of ironwood. Closed cone pines occur in two stands, in addition to several isolated individuals. Island oaks have a somewhat broader distribution, occurring in 17 groves. Willows (*Salix lasiolepis*) and cottonwoods (*Populus trichocarpa*) occur in a few riparian areas, the three cottonwood trees on the island being confined to a single drainage. Holly-leaf cherry (*Prunus ilicifolia* ssp. *lyonii*), toyon (*Heteromeles arbutifolia*), and scrub oak (*Quercus pacificus*) occur occasionally as understory trees in the mixed hardwood community. Shrub and herbaceous understories are generally sparse; the herbaceous layer is composed mostly of alien species.

Reproduction of tree species has been minimal in most stands. Fragmentation within their ranges and lack of structural diversity within the stands threaten continued viability of these communities. It is hoped that the removal of cattle from SRI and sheep from SCI will reverse this situation. An exception to this is the Torrey pines, where significant recruitment is occurring. It is believed that these native trees currently occupy most of their potential range (Clark et al. 1990).

The Channel Islands are known for high numbers of endemic plant species (Table xxx). Additionally, their flora does not include many of the plants which are native on the California mainland.

Table xxx. Numbers of Vascular Plant Taxa on the Channel Islands (Junak, et al. 1995)

	Taxa			
	Native	Endemic	Alien	Total
	Northern Channel Islands			
San Miguel	198	18 (7)	69 (26)	267
Santa rosa	387	42 (9)	98 (20)	485
Santa Cruz	480	45 (7)	170 (26)	650
Anacapa	190	22 (8)	75 (28)	265
	Southern Channel Islands			
Santa Barbara	88	14 (11)	44 (33)	132
San Nicolas	139	18 (7)	131 (48)	270

Santa Catalina	421	37 (6)	185 (30)	604
San Clemente	272	47 (13)	110 (28)	382

Rare species

Many of the park's exceptional values are a product of isolation from mainland populations. A million years of physical isolation from mainland ecosystems allowed island forms to evolve independently. Physical difficulty of travel to and from the islands protects them even now. Isolation and a lack of predators are the conditions necessary for seabirds and marine mammals to form the large colonies found on islands. These factors also create the unique species that evolve on the islands.

Many of the unique species of animals and plants on the island have been listed as rare, threatened, or endangered, as the result of recent habitat destruction by the activities of modern man. A number of species have been extirpated from the islands or surrounding marine waters during the period of human history (Table 3). The island fox, a state of California rare species, is found on three of the five park islands. The island night lizard, a federally listed threatened species, is found on only three islands, of which one of these (Santa Barbara) is in the park. On the same island, an endemic subspecies of song sparrow, formerly federally listed as endangered, is now extinct. By contrast, the endangered California brown pelican has experienced resurgence in fledgling success at its Anacapa nesting colony. While pesticides resulted in the fledging of only one young bird in 1970, hundreds now fledge annually on Anacapa. Two other endangered or formerly endangered bird species, the bald eagle and the peregrine falcon, once nested on park islands. Peregrines, which were removed from the Federal list of endangered and threatened species, have been successfully reintroduced to the park.. The bald eagle, which has been proposed for delisting, may be reintroduced to the northern Channel Islands in the near future. California sea otters, once a significant component of the coastal kelp forest communities, no longer occur in the park.

Table 3. Species extirpated from the Channel Islands during the period of human history

Species	Status	Former Range
Bald Eagle	Threatened	All islands
California Sea Otter	Threatened	Marine Waters; all islands
* Pygmy Mammoth	Extinct	Northern islands
San Miguel Spotted Skunk	Extinct	San Miguel
Santa Barbara Song Sparrow	Extinct	Santa Barbara
Stellar's Sea lion	Endangered	San Miguel

* May have disappeared prior to human presence on islands

Around the islands, park waters provide habitat, on at least a seasonal basis, for several species of endangered cetaceans; almost the entire population of the most well-known of these, the California gray whale (*Eschrichtius gibbosus*), a recently de-listed species, migrates biennially within sight of the park. Copper (*Sebastes caurinus*), brown (*S. auriculatus*), and bocaccio (*S. paucipinis*) rockfish and both white abalone (Haliotis sorenseni) and black abalone (H. cracherodii) have been proposed for federal listing. Black sea bass (*Stereolepis gigas*) were never listed by federal or state authorities, however the fishery was closed when the fish was nearly extirpated from park waters. Recent years have seen a dramatic increase in sightings of these 500-lb fish around the islands. The northern, or Stellar's, sea lion (*Eumetopias jubata*) no longer breeds on San Miguel island and it was listed as endangered because of declines throughout its population range. Guadalupe fur seals (*Arctocephalus townsendi*) have begun to make a comeback however, with pups born on San Miguel Island again after many years with none.

A list of the park's threatened, endangered, and candidate species is in Appendix II. Appendix III is a list of sensitive and rare species that are not listed by USF&WS. A current list of Special Status Plants, Animals and Natural Communities is maintained by the California Department of Fish and Game and posted on the internet at: http://www.dfg.ca.gov/whdab/cnddb.htm.

Alien species

The introduction of alien herbivores to island ecosystems has had catastrophic effects on the vegetation. In the absence of normal population controls such as diseases and predation, livestock overpopulated the islands. Historically, the ultimate control on island herbivore populations has been starvation (Saner 1988). Records for Santa Cruz Island indicate that sheep had been introduced in the early 1830s; by 1875, sheep stocking was around 50,000 head (Hobbs 1983). In 1890, perhaps as many as 100,000 sheep grazed on Santa

Cruz Island (Hochberg et al. 1980a). Pigs had been released on Santa Cruz Island by 1854 (Hobbs 1983). Overgrazing, combined with droughts that occurred in 1864, 1870-72, 1877, 1893-1904, 1923-24, 1935, 1946-48, 1964, (Dunkle 1950; Johnson 1980) and most recently 1986-91 (Halvorson 1993) resulted in episodes of livestock starvation (Johnson 1980). Manipulation of the vegetation by over 150 years of intensive grazing and browsing has resulted in the replacement of native plant communities with non-native grasslands (Minnich 1980; Hobbs 1983).

Several non-native weedy plant species have invaded the disturbed habitats of the islands. On Santa Cruz Island, one of the most obvious problem species is fennel (*Foeniculum vulgare*). Fennel, and other aggressive non-native weed species, displace native species and further threaten the insular ecosystems (Smith 1989; Simberloff 1990). Research methods and results for the control of fennel were the topics of many presentations at the March 1994 Fourth California Channel Islands Symposium (Power 1994 [Brenton and Klinger 1994; Dash and Gliessman 1994; Gliessman 1994]).

The park has undertaken a systematic assessment and priortization of non-native plants for control or eradication. Much progress has been made toward eliminating alien animals from the islands.

Island vegetation has been altered as a result of grazing and exotic species introduction. The islands have over 80 endemic plant varieties. Over 60 species are endangered, rare or threatened, according to the California Native Plant Society. The endangered Santa Barbara Island live-forever, *Dudleya traskiae*, found only on that island, was once thought to be almost extinct, but eradication of the exotic European rabbit population has given this plant the opportunity to recolonize its range. Other outstanding plant resources include the Torrey pine (found in the wild only on Santa Rosa Island and a small section of coast north of San Diego), the Island Ironwood, a genus unique to the islands, and the giant coreopsis, a large tree-like sunflower found only on the islands and the nearby coast.

In contrast to sensitive plant species, which the Park is charged with conserving, alien pest plants (or weeds) are managed for reduction or elimination. For the purposes of this document, weeds are defined as invasive non-native plants taking up space and resources that could be utilized by native species.

Pest species can be categorized by three broad behavior types: 1) opportunistic species that rapidly colonize available habitat, 2) slow spreading species that are very persistent once established, and 3) omnipresent species that have replaced native plant communities over large areas.

Opportunistic species of concern are bull thistle (*Cirsium vulgare*), milk thistle (*Silybum marianum*), Russian thistle (*Salsola iberica*), and spiny cocklebur (*Xanthium spinosum*). These species have seeds that are dispersed over long distances by wind or animals. Consequently the direction of dispersal is random and unpredictable. New seedlings readily establish in any bare soil, such as roadsides, construction sites, streambanks, animal trails, and salt grounds. "Explosions" of these plants may occur in years when favorable weather coincides with availability of disturbed habitat. These four species are currently increasing in size, number, and range of populations. Bull thistle, milk thistle, and spiny cocklebur occur widely, as scattered individuals and in large patches. All of these species have the potential to form dense monotypic stands, completely excluding native island species. None of these species are known to be preferred forage for wildlife or livestock. All may be effectively controlled through a combination of herbicide applications and physical removal. Due to their potential for rapid population growth and domination of plant communities, these species are high priorities for immediate and ongoing control.

Slowly spreading, persistent weed species include fennel (*Foeniculum vulgare),* lavatera *(Lavatera cretica),* black mustard *(Brassica nigra),* tamarisk *(Tamarix aphylla),* kikuyu grass *(Pennisetum clandestinum),* rice grass *(Piptatherum miliacea),* tall fescue *(Festuca arundinacea),* and Bermuda grass *(Cynodon dactylon*). While these species also have the ability to form dense populations, they may take several years to reach this condition. Their seeds are generally larger and heavier than the opportunistic species, and are spread through animal feces or in mud on vehicle tires or animals' feet.

Some alien plant species have become extremely widespread, replacing thousands of acres of native grasslands and shrublands. These species are primarily annual grasses and herbs and are included in the discussion of island communities. Many provide forage for cattle, horses, and elk. Chemical and physical control of these species is currently unfeasible due to their widespread presence.

Marine resources

One of the more prominent habitats surrounding the islands is the giant kelp (*Macrocystis pyrifera*) community which inhabits relatively shallow rock bottom areas. 40 % of all giant kelp beds in southern California occur around the Channel Islands. These submarine forests, reaching the ocean surface from depths over 100ft, provide food and shelter for approximately 125 fish species, and habitat for scores of other animal and plant species, more than 800 in all.

Other significant marine communities include eelgrass (*Zostera marina*) beds that provide nursery habitat for many juvenile fish and elk kelp (*Pelagophycus porra*) forests that inhabit slightly deeper water than giant kelp. Sandy bottoms host a variety of clams and other organisms. The deeper reaches of the park waters extend down to 1000 ft or more as they trail off into submarine canyons. Many commercially important fish inhabit the deeper waters of the park. Invertebrates such as deepwater corals and feather stars cover the reefs but relatively little is known about the water deeper than 130 ft.

The richness of the marine resource offers a haven for many species of marine mammals. As many as 26 species of whales and porpoises can be found, as well as 6 different species of pinnipeds (seals and sea lions). A number of these species are on the endangered species list. San Miguel Island is the only known place in the world where 4 different species of pinnipeds breed and the only area where 6 species are found. San Miguel's Point Bennett is the location of one of the world's most outstanding wildlife displays, with its thousands of seals and sea lions hauled up on the sandy beaches to breed and to pup.

The rich food sources and isolated islands support the numerous seabird rookeries. At least 15 species of seabirds or shorebirds are known to nest in the park. The Channel Islands colonies are significant to the overall populations of many of these species. Both northern and southern range limits are displayed here demonstrating the meeting of biogeographic provinces.

Weather

The climate of the Southern California Bight is of a typical Mediterranean pattern. Winters are cool (the average mean temperature in January ranges from 53-59° F) with a low to moderate amount of precipitation. Depending upon the topographical features of a particular location, rainfall on the islands might range from less than 10 inches to more than 20 inches annually. Fog is a common weather feature, especially at San Miguel and Santa Rosa Islands.

Summers are a little warmer (the average mean temperature in July ranges from 62-70 degrees F) but from May through October very little precipitation occurs due to a stable Pacific high pressure system situated to the northwest of the bight. Throughout the year, wind directions are primarily from the west-northwest, tending to increase throughout daylight hours and becoming east-northeasterly at night.

Air quality

Air quality is important to the park both for the well being of the resources and for the contribution of visibility to the visitor experience. The outstanding vistas, such as those of the island chain from East Anacapa, of Point Conception from San Miguel, or of the four northern islands from Santa Barbara, are among the highlights of a park visit. Views from the high cliffs around the peripheries of the islands, for miles into the surrounding ocean, are an important component of this park's experience.

It is possible that the animals and plants endemic to the islands may be particularly dependent upon good air quality, because of their evolution in an area of isolation, lack of competition, and brisk winds. It has been shown that the ponderosa pine of southern California mountains is adversely affected by air quality deterioration; it might be suspected that members of this genus, such as the Santa Cruz Island pine and the Torrey pine, would be equally susceptible.

Though very little historic record exists with respect to air quality around the Channel Islands, it is probable that the combination of prevailing wind patterns, a low natural fire history, and small human populations allowed for generally good air quality. Since the population and development boom along coastal southern California, however, poor air quality is widespread, and smog often mars the visibility from and around the islands.

The only pollutant that is a human health problem in the Channel Islands is ozone. NO2, CO, and SO2 are monitored in Ventura county but the concentrations are below the federal standards.

The difficulty of access to the islands has resulted in continuation of relatively pristine natural conditions. The quality of air and water remain high, though both of these resources are susceptible to degradation from regional development and pollution.

The phenomenon of "Santa Ana" winds which come from a northeasterly, inland direction, ca greatly affect air quality in the park. These winds usually occur during fall and winter and are characteristically warm and dry and may be of very high velocity near the mainland shore. They primarily affect those islands close to the mainland by carrying out to sea the air pollution usually found onshore. Satellite images show that Santa Ana winds can carry pollutants several hundred miles offshore and have the potential to negatively affect all of the park islands. A bigger concern relative to air pollutants in the Channel Islands is a "Catalina eddy" that can bring pollutants up the coast from the Los Angeles basin and a post-Santa Ana event where the air pollutants that were pushed offshore come slowly back to the coast. Another type of pattern that would bring moderate levels of air pollutants to the Channel Islands is an eastern Pacific High pressure system that causes light winds and poorly dispersed air. Normally, the sea breeze pushes the air pollutants to the coast and keeps low levels of air pollutants in the Channel Islands.

Marine Water Quality

Though the islands lie 14 to 40 miles from the coast, the large population and industrial activities of the area have affects on the water quality. Relatively heavy boat traffic around the islands, natural seeps, boat groundings, or, rarely, major catastrophes such as the 1969 oil spill of Santa Barbara are sources of petroleum pollution. The extensive oil production facilities and tankering through the area pose a concern of future catastrophic oil spills.

Other potentially serious water pollution sources include discharge from ships, sewage disposal or thermal pollution from nuclear plants, but none of these has been found to significantly impact island resources. Urban runoff brings debris, pesticides, nutrients, and potentially harmful bacteria to coastal waters that easily reach the islands during storms. Over a billion gallons of urban waste is discharged daily into the southern California Bight. Heavy metals and organochlorine pesticides still persist from past dumping in the ocean waters here. This resulted in reproductive failure of California Brown Pelicans, Bald Eagles, Cormorants, and Peregrine falcons. And caused problems with seals and sea lions. Banning of DDT in the United States in 1971 has resulted in substantial recovery of Pelicans, Cormorants, and Peregrine Falcons.

Fresh water quality

Since 1993, the Park has been monitoring water quality at a number of sites within the Lobo, Water, and Quemada (Las Cruces) drainages. Water quality in the streams on the island reflect the lack of a functioning riparian community and the impacts of past grazing by cattle (Sellgren 1995). With no riparian vegetation to slow water flows down and capture excess water for later release into the stream, stream flows tend to dramatically peak during storm events. Summer flows tend to be very low, most likely lower than what would be expected if there was adequate riparian vegetation. The lack of riparian vegetation also leads to increased sediment transport during storm events. Total suspended sediment levels were recorded at thousands of times of baseline levels during moderate storm events (less than one inch of precipitation in 24 hours). The scarcity of shrubby and woody riparian vegetation to shade the stream waters leads to high peak water temperatures.

Conductivity, salinity, and total dissolved solids levels indicate that many of the streams on SRI have alkaline properties. The alkalinity of the streams is most likely unrelated to grazing activity, past or present. Dissolved Oxygen levels indicate super-saturated levels during the day. This may reflect release of Oxygen into the stream column by Cladophora algae. Predawn measurements of dissolved Oxygen indicate that levels are suppressed before sunrise. This further supports the impacts of the algae population. Finally, coliform levels indicated that in the streams monitored there was a serious pollution problem associated with cattle feces.

The park has monitored water quality only once immediately following removal of cattle in 1998. It is expected that many of the water quality parameters will improve with time. Recovery of riparian vegetation is already occurring at a rapid pace.

Baseline information

The park's 1980 legislation contained unusual mandates; it required that the park develop a natural resources study report for the park, including 1) an inventory, including population dynamics, for all species in the park; 2) an assessment of present conditions and probable future trends of populations, and 3) recommendations as to what actions should be considered for adoption to better protect the natural resources of the park. The report was to be submitted to Congress biennially for ten years.

The park recognized this legislation as an opportunity to develop a model system for monitoring natural resources in national parks. It was also recognized that restoration and protection of park resources required an ecological monitoring program to assess the effectiveness of these efforts, and to determine limits of natural variation, diagnose abnormal conditions, and prescribe potential remedial treatments. 15 mutually exclusive components of the park’s ecosystem were identified and prioritized for establishment of monitoring protocols. The 15 ecosystem components (in priority order) were: pinnipeds, rocky intertidal, seabirds, marine invertebrates, land birds, terrestrial vegetation, marine vegetation, marine fishes, terrestrial invertebrates, reptiles and amphibians, terrestrial mammals, visitors, fisheries, weather, and water quality. Monitoring protocols were written and implemented for pinnipeds, rocky intertidal, seabirds, visitors, weather, and kelp forests (marine invertebrates, marine vegetation, and marine fishes). In 1993, the park initiated monitoring of land birds, terrestrial vegetation, terrestrial vertebrates (reptiles and amphibians, terrestrial mammals), and sandy beaches.

Because of the park's unique mandate and the considerable body of work done by local scientific organizations (especially the Santa Barbara Botanic Garden, Santa Barbara Museum of Natural History, and U.C. Santa Cruz Island Reserve among others); Channel Islands has a much better knowledge of its natural resources than do most national parks. A recent survey of the status of natural resource databases in the Western Region (Stohlgren and Quinn, 1991) found that CHIS had the most complete inventory of all the Western Region parks. Nonetheless, the park does not meet the minimum level of baseline information as described in "Standards for Natural Resources Inventory and Monitoring". The park however does have easily accessible bibliographies of past research with key word indices.

Following is a summary of the CHIS natural resources databases (Stohlgren, T.J. and J.F. Quinn. 1991) (Table 3) and an explanation of codes used. In many cases, Channel Islands does not meet minimum NPS Inventory & Monitoring standards (i.e. a score >1) for taxonomic completeness, geographic completeness, ecological completeness, or seasonal completeness.

Table 3. Status of Resource Inventories at Channel Islands National Park as of 1990

BIOLOGICAL GROUPS	TAX COMP	GEO COMP	ECO COMP	SEAS COMP	INV HIST	INV YEAR	DOC YEAR	NUMB VOUCH	NUMB SPEC
AMPHIBIANS	1	2	2	2	2		1967		3
BATS	1	4	4	2	5		1980	0	8
BIRDS	1	1	1	1	1		1989	0	315
CETACEANS	1	1	1	1	2		1987	0	30
KELP FOREST SPP-MAMM	3	3	2	2	3	1986	1988	0	3
KELP FOREST-AQINVERT	1	1	1	3	1	1986	1988	0	455
KELP FOREST/ALGAE	1	1	1	3	1	1986	1988	0	214
LAND MAMMALS	2	3	3	2	2		1967	0	20
MAMMALS	1	1	1	1	1			0	64
MARINE INVERTS	3	3	3	1	1	TEXT	1982	0	500
NONVASCULAR PLANTS	3	3	3	1	1	TEXT	1982	0	350
PINNIPEDS	1	1	1	1	4		1988	0	6
REPTILES	1	2	2	1	2	1967	1980	0	7
ROCKY INT. TIDAL-BIRD	3	3	2	2	3		1989	0	19
ROCKY INTERTIDAL-MAM	3	3	2	2	3		1989	0	3
ROCKY INTIDAL-ALGAE	3	3	2	2	3		1989	0	112
ROCKY INTIDAL-AQINVT	3	3	2	2	3		1989	0	110
SANDY INTIDAL-AQINVT	1	4	2	2	4		1990	0	30
TERREST ARTH & SNAIL	3	3	3	2	2	1978		0	750

From Stohlgren and Quinn, 1991

Biological Inventory Status Codes

TAXONOMIC COMPLETENESS:

1. inventory probably taxonomically complete, covers all group within this biological group
2. inventory > 80% taxonomically complete, for this biological group
3. inventory 50%-80% taxonomically complete,
4. inventory < 50% taxonomically complete,
5. inventory contains good information about a few taxa such as Families, or Genera,
6. inventory poor or nonexistent,
7. inventory status unknown,

GEOGRAPHIC COMPLETENESS:

1. inventory has been generally throughout the park and adjacent lands for this biological group
2. inventory has been throughout > 80% of the park,
3. inventory has been throughout 50%-80% of the park,
4. inventory has been limited to only a relatively few areas in the park,
5. collection has been sporadic with no areas being inventoried well,
6. status of geographical completeness in inventory is unknown.

ECOLOGICAL COMPLETENESS:

1. inventory has been completed in all major ecological/community types, in the park, for this biological group
2. inventory has been completed in > 80% of the major ecological/community types
3. inventory has been completed in 50%-80% of the major ecological/community types,
4. inventory has been limited to only a relatively few of the major ecological/community types,
5. collection has been sporadic with no major ecological/community type being inventoried as well,
6. status of ecological completeness in inventory in unknown.

SEASONAL COMPLETENESS:

1. inventory has been completed over all appropriate seasons, in the park for the biological group
2. inventory has been completed in some of the appropriate season's,
3. inventory has been completed in only one of the appropriate season's of the year,
4. collection has been sporadic with no season being inventoried well,
5. status of seasonal completeness in inventory is unknown,
6. N/A

HISTORY OF INVENTORY:

1. inventory/observations have been ongoing over the history of the park
2. inventory/observations have been ongoing over the last 10-20 years
3. inventory/observations have been ongoing over the last 5-10 years
4. inventory/observations have been ongoing over the last 5 years
5. inventory/observations have occurred more than once
6. inventory/observations have occurred only once
7. inventory/observations have never occurred
8. inventory/observations status is unknown
9. scattered observations over time

VOUCHER SPECIMENS: (enter number of voucher specimens in park)

NUMBER OF SPECIES:

How many species are listed on the park's checklist for this biological group?

Table 4. Summary Table of Natural Resources Baseline Information

Meets, does not meet, or exceeds the recommended minimal set of natural resources information in the Natural Resources Inventory and Monitoring Guideline for the NPS			
INVENTORY COMPONENTS	MEETS	DOES NOT MEET	EXCEEDS
Historical Database	√		
Species Information		√	
Species List	√		
Biological Surveys		√	
Species Distribution	√		
Vegetation Maps		√	
Cartographic Maps	√		
Soils Map		√	
Geology Map		√	
Water Resources Inventory		√	
Water Quality Data		√	
Air Quality Stations	√		
Air Quality Data		√	
Precip./Meteorological Data	√		

Status of Natural Resources

As large natural ecosystems, national parks have many values to society. They are pleasuring grounds for outdoor recreation and emotional retreats from the stresses of modern, urban life. National parks also protect the reservoirs of wild genetic material that are the basis of the nation's future in bioengineering, agriculture, aquaculture, and pharmaceuticals. Most importantly though, national parks are vital ecosystem standards that warn us of impending disasters, like ecological "miner's canaries". However, if we do not watch the canaries, their warnings will be lost.

Channel Islands has performed the miner's canary function on several occasions. In the late 1960's, researchers visiting the breeding colony of California Brown Pelicans on Anacapa Island noted that the eggs were being crushed by the incubating parent. Although numerous adults of this long-lived species were flying around and establishing nests, they were unsuccessful at rearing young. In 1971, only one chick successfully fledged.

Subsequent investigations identified DDT in the environment as the cause of the thin egg shells. This finding was a prime reason for growing public concern about environmental issues and was the first link between a man-made chemical and widespread biological impacts. The resulting banning of DDT's and PCB's has resulted in substantial recovery of species such as Bald Eagles, Peregrine Falcons, and California Brown Pelicans. Recovery of these species has lagged behind other areas because of the persistence of DT's and PCB's in marine sediments and the food chain.

The park's monitoring program also provided an early warning of declines of Black Abalone, White Abalone, Island foxes, harvested marine resources, and potential impacts to seabirds by squid light boats.

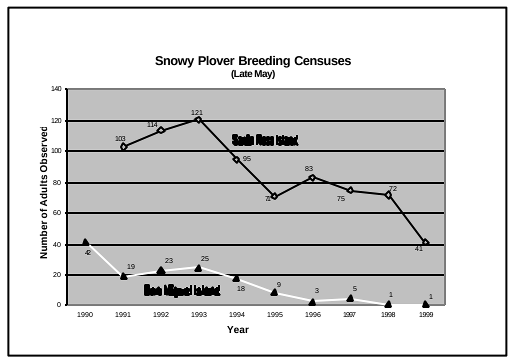
The monitoring program at Channel Islands National Park continues to provide basic information to park managers and scientists regarding the health of the island and marine ecosystems. Following is a synopsis of information on the health of selected ecosystem components in the park.

Western Snowy Plover

Snowy Plovers are small, pale, sand-colored shorebirds that inhabit sparsely vegetated sandy areas (shores and dunes) on San Miguel, Santa Rosa, and Santa Cruz Islands (Spear 1981). They are also known to nest on San Nicolas Island. Their nests, which are inconspicuous and extremely difficult to locate, appear as slight depressions in the sand often near shells, vegetation, rocks or driftwood. Their uniform sand colored upper surface effectively camouflages them when they are standing still and they are readily visible only when moving (i.e., walking or running) or when in flight.

Concern for the coastal subspecies prompted US Fish and Wildlife Service to list the Western Snowy Plover as "threatened" under the Endangered Species Act in 1993. Despite this protection, numbers of breeding Snowy Plovers on San Miguel and Santa Rosa, as well as on the mainland, have continued to decline at a dramatic pace.

Figure 3. Adult western snowy plovers on San Miguel and Santa Rosa Islands; 1990 - 1999



The breeding season lasts from April to July. Usually three eggs are laid, but often there are only two; both parents incubate and care for the young. Snowy Plovers will often feign injury to distract intruders from the nest site; a tactic that may be effective in evading the island foxes (*Urocyon littoralis*) on the Channel Islands. Adults forage along the water's edge, and when going to or from the surf line they do so with distinctive rapid movements; like other plover species, they start, run several feet, then abruptly stop.

There are many threats to Snowy Plovers, both natural and human in origin. Adults moving off of nests because of disturbance events may expose eggs to hazardous winds or predators. Santa Rosa and San Miguel have 20-30 knot winds on a regular basis throughout the plover nesting season. These high winds cause the eggs to be sandblasted or blown out of the nest when the adult steps off of the nest.

Increasing numbers of northern elephant seals (*Mirounga angustirostris*) and breeding harbor seals (*Phoca vitulina*) on the south beach areas at San Miguel Island (Crook Point to Cardwell Point) has probably reduced Snowy Plover nesting in those areas. This has begun to happen in recent years at Santa Rosa Island (Sandy Point to Cluster Point). If pinniped occupation of the south beaches continues to increase at Santa Rosa, plover nesting habitat could be reduced there as well.

However, the expansion of elephant seals does not completely explain the decline of snowy plovers on Santa Rosa Island. It has been hypothesized that Santa Rosa Island is a sink for plovers because of the environmental conditions that make it difficult for plovers to nest successfully. If this is the case, then the decline of plovers on the mainland would result in a decreased flow of birds into the island breeding population.

It is also possible that factors on the island, such as predation, have increased. The park needs to continue to monitor the island plovers and work with shorebird researchers to determine what factors are affecting the breeding population at Santa Rosa. We also need to determine the breeding effort on Santa Cruz Island.

Island Fox

The island fox (*Urocyon littoralis*), a diminutive relative of the gray fox (*U. cinereoargenteus*), is endemic to the California Channel Islands. It is distributed as six island populations each varying in size from less than a hundred to a few thousand individuals. The fox exists as a different subspecies on each of the six islands, a distinction upheld by morphological and genetic work (Wayne et al. 1991, Collins 1993). Due, in part, to its limited distribution and small numbers it has been listed as a threatened species in California (California Department of Fish and Game 1987) and was formerly considered a candidate for listing as a federally threatened or endangered species (Federal Register 1989). A substantial amount is known about this species' population ecology and evolutionary history due to recent work on island fox genetic variability (Gilbert et al. 1990), evolution (Wayne et al. 1991), disease incidence (Garcelon et al. 1992), population density and conservation (Roemer et al. 1994) and political issues in the management of this unique species (Coonan and Schwemm 1995). Channel Islands National Park encompasses five of the eight California Channel Islands and includes three islands which harbor fox populations.

The island fox was selected as a component of the Park's long-term ecological monitoring program because of the species' endemic nature, its small population size on several islands, its state-listed status as threatened, and its vulnerability to canine diseases. The Park began monitoring island fox populations on San Miguel Island in 1993. The island fox population on San Miguel has declined sharply since then (Coonan et al. 1998) with the adult population falling from 450 in 1994 to approximately 20 in 1999. Monitoring data from Santa Cruz Island and survey data from Santa Rosa Island indicate that island foxes are undergoing similar catastrophic declines on those islands as well. Populations are so low that the species may warrant listing as endangered under the Federal Endangered Species Act.

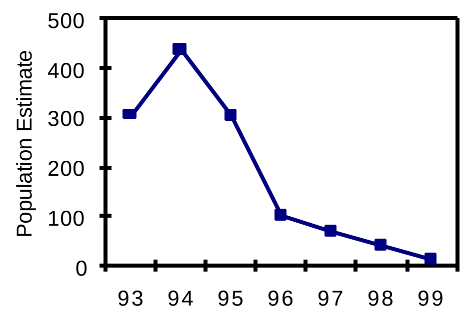


Figure 4. Islandwide population estimate for adult island foxes, San Miguel Island

In fall 1998 the park initiated a radiotelemetry study of island foxes on San Miguel in order to determine causes of mortality. Four of eight radiocollared island foxes were killed by golden eagles in a four-month period, and another two died of unknown causes. In a recent study of island foxes on Santa Cruz Island, golden eagle predation was identified as cause of death for 21 of 29 island foxes carcasses (Roemer and Garcelon, in rev.).

This level of golden eagle predation is unnatural. Golden eagles have never bred on the Channel Islands and their recent appearance as winter visitors may be due to a prey base, feral pigs (*Sus scrofa*) that was not present prehistorically. The absence of bald eagles (*Haliaeetus leucocephalus*), which bred historically on the islands and whose presence may have kept golden eagles away, is thought to be another contributing factor driving increased golden eagle predation. Moreover, on San Miguel and on portions of the other northern islands, historic sheep grazing has changed the predominant vegetation from shrub communities to non-native grasslands, which offer much less cover from aerial predators.

Moreover, the current activity patterns of individual foxes make them more prone to predation. Home ranges for San Miguel foxes from the fall and winter 1998-1999 are much larger than previously recorded for island foxes. This is most likely due to the fact that foxes now exist on San

Miguel at very low densities, and are traveling greater distances to find potential mates.

Canine diseases and/or parasites may also be factors in the decline. A disease and parasite survey of island foxes on all six islands, funded by the Canon Expedition Into The Parks donation program, revealed a very high incidence of heartworm (*Dirofilaria immitis*) in foxes on the three northern Channel Islands where they are declining (Roemer et al., in prep). In contrast, foxes from only one of the three southern islands have tested positive for heartworm. Another previously unknown parasite has also been recently identified in island fox populations, and could be predisposing foxes to predation (L. Munson, UC Davis, pers. comm.).

The island fox subspecies on San Miguel Island is on the verge of extinction, and the populations on Santa Rosa and Santa Cruz are also at risk. A current population viability analysis estimates time to extinction to be five years or less for the San Miguel subspecies, and 12 years for the Santa Cruz subspecies (G. Roemer, UCLA, unpubl. data). Due to the ongoing and significant mortality of island foxes on San Miguel, and the low population size, chances for persistence of this population are slim without aggressive management actions.

Concerned about the potential loss of three subspecies of island foxes from its lands, the Park convened an island fox recovery team in April 1999 to consider the available information and develop strategies to recover island fox populations to viable levels. The team concluded that predation by golden eagles is the primary mortality factor now acting on the population, and that disease or parasites may be compounding the effects of predation; that natural recruitment is low; and that the most effective conservation measure that could be taken right now is to increase survival of pups, juveniles and adults by reducing or eliminating golden eagle predation. At the same time, the team recognized that the size of the fox populations on these three islands is critically small; the natural reproductive potential is low; our knowledge of all of the factors contributing to the population decline may be incomplete; and the effectiveness of proposed golden eagle management efforts in reducing or eliminating predation is yet to be seen. Establishment of a fox sanctuary and captive breeding program was identified as necessary to safeguard individual foxes and to augment natural recruitment into the population.

Upon receiving these recommendations, the park began taking emergency recovery actions in 1999. Pens have been constructed to provide a sanctuary and captive breeding facility for foxes on San Miguel Island. With funds from NRPP, the park will be relocating Golden Eagles and breeding foxes in captivity.

Peregrine Falcon

Along with bald eagles and ospreys *(Pandion haliaetus*), peregrine falcons (*Falco peregrinus anatum*) were once a common breeding species on the Channel Islands, with perhaps as many as 11 Peregrine pairs nesting simultaneously on the islands which now comprise Channel Islands National Park. However, all three species had been extirpated on the islands by the middle part of this century, the local declines of those species mirroring similar declines on the mainland. As a result, the Bald eagle and Peregrine Falcon are both federally listed as endangered species.

Ospreys disappeared from the Channel Islands by 1930, their primary cause of decline being mortality from shooting. Bald eagles were extirpated by 1960, due to shooting by sheepherders and visitors, egg collection, nest destruction and disturbance, removal of young, trapping, and poisoning, as well the insidious environmental effects of the organochlorine pesticide DDT. Island peregrine falcon populations disappeared by 1955, their decline also hastened by DDT.

The widespread use of DDT in the mid-part of this century caused bioaccumulation of its metabolite, DDE, and resulted in eggshell thinning, reproductive failure, and population declines in peregrine and bald eagle populations in the U.S. Although the use of DDT was restricted in the U.S. by 1972, raptors were still exposed to DDT ingested by prey species migrating from Central and South America, where applications were still legal. Moreover, levels of DDT were exceptionally high in the marine ecosystem of the southern California bight, due to the effluent produced by a DDT manufacturing company in Los Angeles.

By 1970, 95% of the breeding peregrines in the U.S. had disappeared, and only two pairs could be located in California, a state in which as many as 300 pairs may have formerly bred. In order to accelerate peregrine recovery in the West, the Santa Cruz Predatory Bird Research Group embarked on an ambitious peregrine release program in 1975, with source birds coming from the removal and incubation of thin-shelled eggs from wild nests and maintenance of a captive breeding population. By 1993 almost 800 peregrines had been released into former habitat in the western U.S.

Some recovery efforts have targeted historic peregrine habitat on the Channel Islands. The islands provide ideal nesting habitat for peregrine falcons, which prefer to establish their nesting "scrape" sites on vertical rock faces with adequate ledges, adjacent to large open spaces for hunting. To initiate peregrine recovery on the islands, SCPBRG released six peregrine hatchlings on San Miguel Island in 1985 and 1986. By 1990, peregrines had established five natural nest sites in the park, and since 1993 at least 8-10 eyries have been occupied annually in the northern Channel Islands. This exceeds the downlisting goal of five active nest sites on the Channel Islands set by the Pacific Coast Recovery Team for Peregrine Falcons.

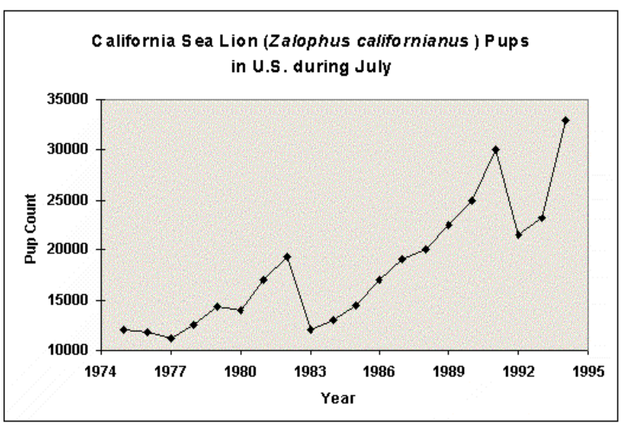
In 1999 the peregrine falcon was removed from the list of endangered and threatened species because recovery goals had been met. There are currently approximately 1,650 pairs in the U.S. and Canada, well above the recovery goal of 631 pairs.

California Sea Lion

The playful California sea lion, *Zalophus californianus californianus*, is one of the more ubiquitous sights around the Channel Islands. Significant breeding rookeries occur on Santa Barbara and San Miguel Islands and other smaller or non-breeding colonies occur on all the park islands. The peak breeding season is in June each year.

The population has been growing steadily since the 1970s when the Marine Mammal Protection Act dramatically reduced fishery interactions and harvest. El Niño southern Oscillation events dramatically reduce pups born and their survival, but the population as a whole has been able to recover quickly.

Figure 5. Total number of California Sea Lion pups in the U.S. between 1975 and 1994.



The National Marine Fisheries Service (NMFS) monitors sea lions (as are the other marine mammals) and the population is estimated based on pup counts. The estimated U. S. population is 160,000-185,000 with 80,000 occurring on San Miguel.

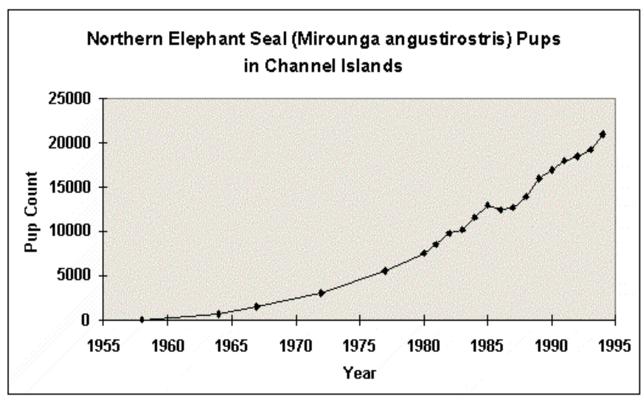
Marking studies at Point Bennett, ongoing since 1987, are providing important data on the survival and age structure of the population as well as breeding longevity of females and territorial tenure of males.

Elephant Seal

Northern elephant seals (*Mirounga angustirostris*) give birth in California and Baja California (Mexico) primarily on offshore islands, from December to March. Adults make a double migration each year to the Gulf of Alaska, returning to the Channel Islands to breed in the winter and to molt in the spring/summer. The entire population was all originally derived from a few tens or hundreds of individuals surviving in Mexico after being nearly hunted to extinction.

More than 85% of the California population is located in the Channel Islands. Within the park, elephant seals breed on Santa Barbara, San Miguel and Santa Rosa islands. The later colony has been growing and spreading along the southern shore since the mid-1990s. Population growth has been exponential since the mid-1960s.

Figure 6. Northern Elephant Seal pups at the Channel Islands.



Because elephant seals do not feed in southern California, El Niño effects of driving prey away from the islands did not impact them. However, severe storms did cause large pup losses during the 1983 and 1997 El Niños.

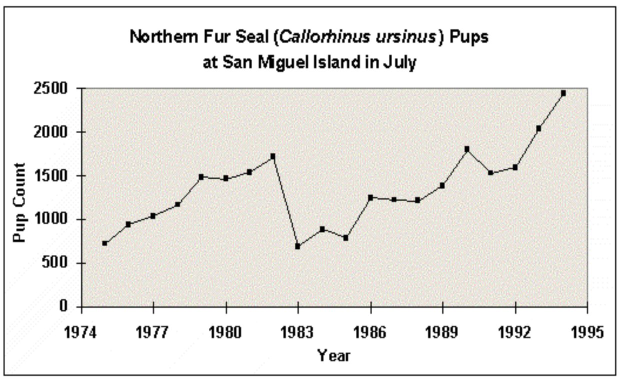
Northern Fur Seals

Northern fur seals (*Callorhinus ursinus*) occur from Southern California north to the Bering Sea and west to Japan. Adults usually occur onshore during a 5 month period, principally during the breeding season (May-October), then spend the next seven months at sea.

The population of fur seals on San Miguel (approximately 11,000) has increased steadily since the early 1970's except during the El Niño Southern Oscillation events of 1982-1983 and 1997-1998.

The number of fur seals at Point Bennett in 1999 was over 70% higher than 1998 but production was still nearly 65% less than the 1997 pre-El Niño counts.

Figure 7.



California Brown Pelican

On the West coast of North America, Pelican colonies are located on West Anacapa Island, Santa Barbara Island and on islands off the coast of Baja California. Therefore the only breeding colonies of Brown Pelican in the western US. Are supported by the Channel Islands. These colonies almost disappeared in the 1970's .

Alarmed at the decline, biologists Bob DeLong, Frank Gress and others began visiting West Anacapa Island (WAI) in 1969 to document the population and determine why the breeding effort by Brown Pelicans had radically decreased. They found the few eggs that were being laid were unlikely to survive to hatching because of reduced eggshell thickness.

Brown Pelicans use their highly vascularized feet to incubate the eggs by standing on them. Eggshell thinning obviously makes the eggs more fragile and more likely to crack or break when a 9 pound bird stands on them, however delicately so.

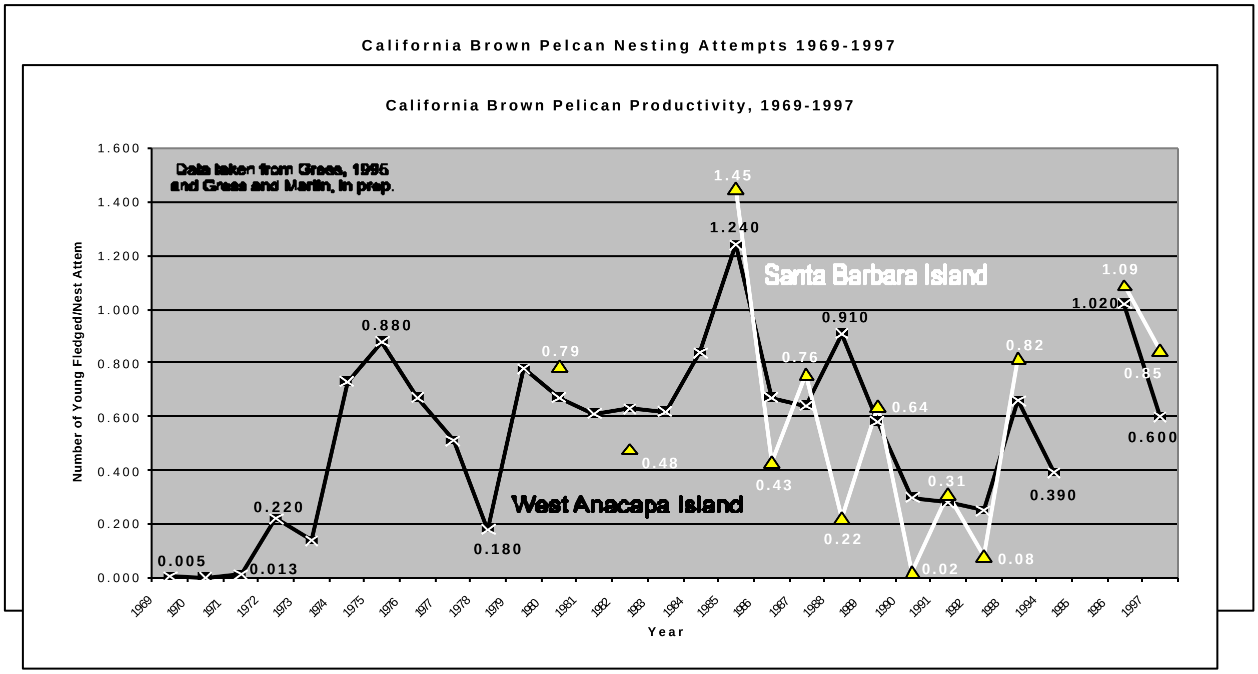
Research projects carried out by UC Davis staff and students revealed the presence of high levels of DDT/DDE in the marine environment. And thus the direct link to egg-shell thinning was made.

The number of birds in the breeding population has steadily increased to 4000-6000 nesting attempts every year at West Anacapa Island. This is in sharp contrast to the early 70's in which there were only about 100 nest attempts. On Santa Barbara Island, the once ephemeral colony produces 400-700 nests every year.

Management actions taken include restricting access to WAI. A closure keeping boats well offshore was created to protect fledglings in the vicinity of the nesting colony.

In 1986, UC Davis researchers worked together with Park Service scientists to standardize monitoring protocols for Brown Pelicans as part of the National Park's Seabird Monitoring Program. Monitoring involves visiting the nesting sites once a month for the duration of the nesting season which can extend from January-September. Counts of adults, nests, and chicks provide information on nesting effort. Determining broodsizes and aging individual chicks lead to an estimate of fledging success and, therefore, reproductive success of the adults.

Difficult access to West Anacapa and the increasing population is forcing us to look at new monitoring methods. Brown Pelicans became Federally protected under the Endangered Species Act in 1972.



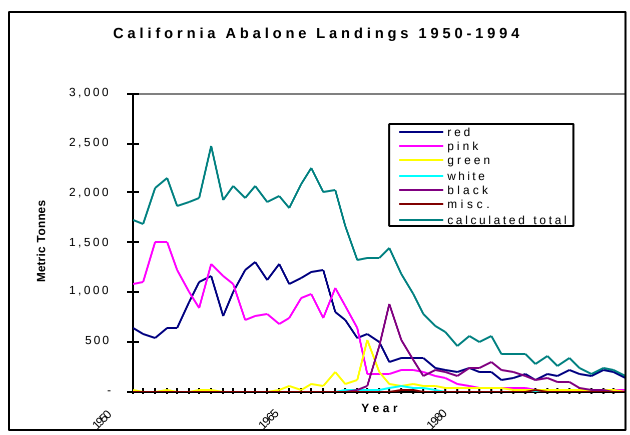
Abalone

Abalone are slow growing, long-lived, and once occupied extensive areas, constituting a large portion of the consumer biomass. These large herbivorous gastropod mollusks feed on the fronds of giant kelp and other algae. Abalone have played important roles in the large and valuable California fishery for thousands of years starting with the Chumash Indians.

Black abalone, *Haliotis cracherodii*, were important structural components of rocky intertidal communities in southern California. Since the mid-1980s, over 99% of the black abalone populations have vanished from the Channel Islands (Richards and Davis 1983). The decline was attributed to Withering Syndrome, a bacterial infection that apparently prevented assimilation of food and caused the abalone to wither and eventually die (Friedman *et al*. 1997). In 1990, after a decline of 90% of the populations elsewhere were gone, the state closed Santa Barbara, Anacapa and Santa Cruz Islands to further commercial harvest. Harvest continued on remaining populations at Santa Rosa and San Miguel Islands until black abalone harvest in the state was closed in 1993.

Other abalone species were also affected by Withering Syndrome but apparently not as severely as black abalone. Never the less, pink, *H. corrugata*, green, *H. fulgens* and red abalone, *H. rufescens* populations dwindled except in a few areas around San Miguel Island. Surveys were made for white abalone, *H. sorenseni*, which occurs in deep water and only a few individuals were found in areas that previously supported large populations (Davis *et al*.1996). The state closed the fisheries for pink, green and white abalone in 1996 and all abalone harvest south of San Francisco was banned in late 1997.

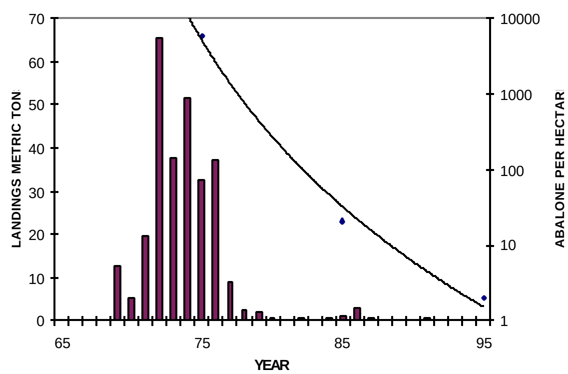
Figure 10.



Marine Resources

Populations of sea life are disappearing from Channel Islands National Park. Legal fishing drove white abalone to the brink of extinction in the 1970s. Sport and commercial divers, using scientifically determined size and bag limits, closed seasons, and limited numbers of permits, similarly collapsed green abalone and pink abalone populations in the 1980s, effectively closing lucrative fisheries before management agencies acted to stop fishing. Scientifically managed fishing also depleted red abalone and reduced the viable population to a single park island before that fishery was closed in 1997 to prevent permanent loss. Fishing effort, redirected from recently failed abalone fisheries, reduced large red sea urchin abundance more than 80% and the slide continues downward. To survive when high-valued species, such as abalone, are depleted, fisheries must shift to lower valued species, such as sea cucumbers. Consequently, ever more sea life must be taken to make the same amount of money. For example, 20,000 tons of urchins must be taken to equal the value of 2,000 tons of abalone. Fishers catch many fewer and much smaller nearshore rockfishes, California sheephead, white seabass, kelp bass, and other popular fishes now than just a few years ago. We are fishing down our resources both economically and ecologically. Simply refining size and bag limits, or adjusting closed seasons will not rebuild these depleted populations. We need new management strategies to rebuild depleted resources and to sustain fisheries.

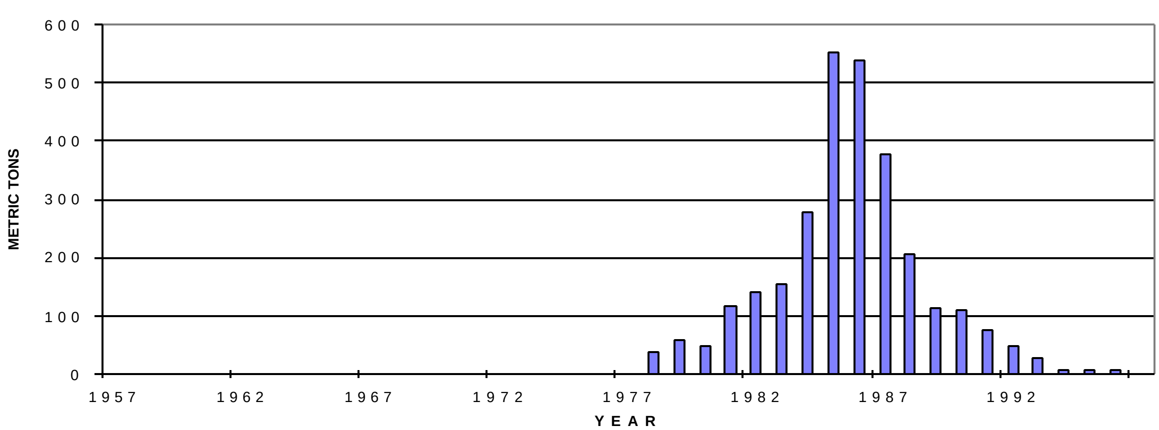
Figure 11. White abalone numbers fell so low (line) following 270 metric ton landings (bars) in the 1970s that they have not reproduced since then, and are now approaching extinction.



As with most environmental issues, declining sea life populations in the park have several related causes. Pollution, fishing and global environmental events, such as El Niño, are all involved. El Niño events and pollution affect all park waters. Fishing is allowed by the State of California in 99.998% of the park's 125,000 submerged acres. Only 37 acres of the Anacapa Island Ecological Reserve are reserved from fishing. By comparing sea life populations in the fished zone of the park and in the no-take part of the reserve, and by monitoring patterns of change among populations of sea life taken by fishing (e.g., red urchins) and similar species not taken by fishing (e.g., purple urchins), we can separate and measure the different effects that fishing and environmental factors (such as pollution and El Niño) have on the park. We conclude from this kind of evidence that fishing is the primary cause of declining sea life in the park.

Big red sea urchin populations have declined more than 80% in the fishing zone at Anacapa Island since fishing began, while they increased in the unfished reserve(in spite of El Niño and pollution.

Figure 12. The angel shark fishery is another example of serial depletion. It lasted only a few years, and the population was already depleted when gill nets were banned in 1994.



A 1998 report from the Southern California Coastal Water Research Project indicated that pollution from DDT and PCBs in the southern California Bight is 95% less now than it was 20 years ago. California brown pelicans, nearly wiped out by DDT in their food during the 1960s, have recovered during the last 25 years, eating fish from the coastal ocean. Peregrine falcons, also endangered by DDT pollution in the 1960s, are once again common sights along island sea cliffs, while bald eagles nesting still can not reproduce on the Channel islands because DDT contaminates their food. More still needs to be done to reduce pollution in this region. However, the improved health of top level predators reflects a cleaner food web. Since we have made such substantial progress in improving coastal water quality, there is no reason to believe pollution caused the recent declines of sea life in the park.

Declines are common for many species in the fished zones of the park, but not in the unfished zone. For example, large red sea urchins provide shelter for juvenile abalone, urchins, and lobsters under their spines. Removing them, reduces survival of important members of the kelp forest community. When the red urchin fishery began in the early 1970s, the average hectare (an area the size of two soccer fields) of kelp forest contained more than 12,000 large red urchins. Today, most kelp forests in the park harbor fewer than 2,000 large red urchins per hectare where fishing is allowed, while the no-take marine reserve at East Anacapa Island still contains 15,000-20,000 large red urchins per hectare. Clearly environmental conditions and pollution that affect the reserve and fished zone populations equally did not cause a decline in red sea urchin populations. Fishing caused the decline.

Unfished purple urchin populations increased and fluctuated wildly in the fishing zone where fishing removed red urchin competitors and predators, but remained low and stable in the unfished reserve.

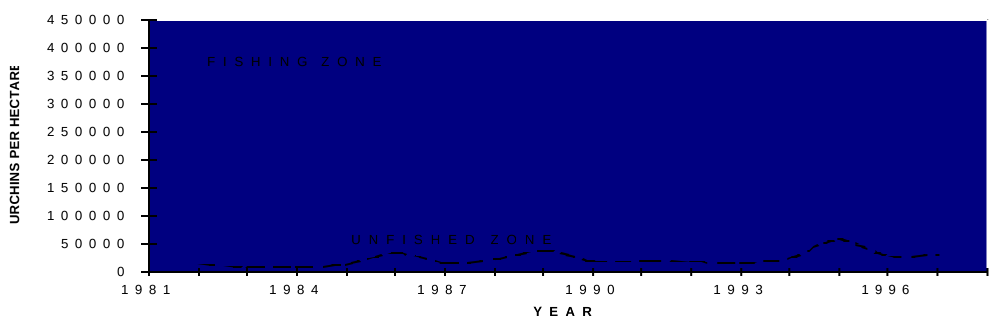


Figure 13. Unfished purple urchin populations increased and fluctuated wildly in the fishing zone where fishing removed red urchin competitors and predators, but remained low and stable in the unfished reserve

Further evidence that fishing is the primary cause of recent sea life declines in the park is found in population trends of kelp forest species that are not taken by fishing. In the park's fished zone, populations of sea life not taken by fishing generally increased or maintained their populations over the past 20 years. For example, purple sea urchins, too small to be profitably processed for food, increased 100 fold, grazed kelp forests down to barren rock, and crashed. This pattern was repeated several times in the fished zone, where red urchin competitors and predators were removed by fishing. Purple urchins in healthy kelp forest in the East Anacapa Island no-take reserve remained stable at low levels through El Niño events in the 1980s and 1990s. Nearby kelp forests in the fished zone, weakened by selective removal of fishery-targeted species, disappeared for many years, barely recovering, if at all, before the next El Niño.

California's current fishery management in the park was based on the best available scientific information at the time the regulations were promulgated. This information was developed in the 1940s, 50s and 60s by well funded and adequately staffed marine research organizations. Those leading scientists of their day took species-based maximum yield models introduced in the late 19th century, refined them and applied growth, mortality, and other parameters of population dynamics to set size and bag limits, establish fishing seasons, and restrict gear to maximize sustainable fishery landings. Unfortunately, those management strategies failed to protect the minimal reproductive capacity of exploited species needed to sustain many fished populations. These traditional fishery management tools sustained some fisheries by means of serial depletion, but failed to sustain the resources and ecosystem integrity. Subsequent research in ecology discovered the importance of competition and predation in sustaining communities and the importance of populations in sustaining species. This knowledge revealed fatal flaws in the early species-based fishery management schemes.

Now we are learning that sustainable exploitation requires habitat or community-based yield models that have yet to be developed. Scientists have found in many parts of the world, such as the Philippines, Australia, New Zealand, and South Africa, that no-take areas not only conserve biodiversity, but can also sustain fisheries. We have no examples of how successful this strategy can be in the United States because we have virtually no large unfished areas along our coasts. Currently, there are 104 "marine protected areas" within California waters, but only 0.2 percent of these "protected" are truly protected as are no-take zones.

Table 5: Santa Rosa Island Ozone Summary (Santa Barbara County Air Pollution Control District)

Year	% of Days Moni-tored	Number of Days Standard Exceeded			1-hr Ozone Concentrations ppm				8-hr Ozone Concentrations ppm		
		State 1-hour	Federal 1-hour	Federal 8-hour	1st High	2nd High	3rd High	4th High	1st High	2nd High	3rd High
1998	96	0	0	0	0.082	0.081	0.080	0.077	0.075	0.074	0.067
1997	98	0	0	0	0.081	0.080	0.079	0.076	0.074	0.067	0.067
1996	70	2	0	0	0.099	0.096	0.093	0.087	0.082	0.079	0.078

Air Quality

The history of air quality monitoring on the Channel Islands goes back to the period of 1988-1992 when a air quality station was located on East Anacapa Island. This station monitored ozone, sulfur dioxide, hydrocarbons, and nitrogen oxides. This station was removed when the Coast Guard converted the Anacapa lighthouse to solar power, and removed the power supply for the air quality station. In 1996, in cooperation with the Santa Barbara County Air Pollution Control District, an ozone monitoring station was built on Santa Rosa Island.

As part of the California Air Quality Monitoring network, the Santa Rosa Island ozone monitoring station has been providing continuous ozone monitoring since April 1996. Although the site is located in a remote location, this site has had excellent data recovery rates and its calibration tests have been well within the equipment standards. Annual audits conducted by the California Air Resources Board (ARB) have been rated as excellent (Craig 1998). Table xx summarizes ozone data for the years 1996-1998. Historical and current ozone information on Santa Rosa Island is available at Santa Barbara Counties Air Pollution Control District's web site: www.sbcapcd.org/airdata/stasumsr.htm.

In addition to the continuous ozone monitoring station on Santa Rosa Island, the Park has participated in the Passive Ozone Sampling Program administered by the Air Resources

Division (ARD). This program allowed the park to monitor ozone levels on all of the Park's islands for approximately a 5-month period in 1997 and 1998. Data from the passive ozone samplers will allow the park to make ozone comparisons between the islands (inter-island comparison). The Park, in an effort to gain a better understanding of ozone changes on an island, deployed two passive units on Santa Rosa Island. The intra-island comparison will show if an ozone gradient exists based on elevation on the island. Passive ozone sampling data is being analyzed and archived by the ARD. The Park will continue to utilize the passive samplers because it is a cost effective means to obtain ozone information on remote islands.

The proximity of the Channel Islands to heavily populated urban areas, commerce shipping, and off-shore oil and gas development makes them vulnerable to air pollution. In addition to seeking redesignation as a Class I airshed under the Clean Air Act, the park will continue to seek and participate in cooperative efforts to monitor air quality on all of the Park's islands.

Terrestrial Vegetation

Channel Islands National Park is home to ** Federally listed plant species. ** species are state listed and ** species are on the Parks Sensitive Plant list. Monitoring of rare plant species is necessary in order to assess the current status in terms of population numbers and distribution for these species; to understand the environmental processes affecting them; and to document any changes to their present condition.

Monitoring of the botanical resources on the Channel Islands has been inconsistent. However, in 1995 the Biological Resource Division of the USGS (USGS/BRD) in cooperation with the Park began a systematic monitoring of 14 rare or endemic plant species within the park: Castilleja mollis, *Arctostaphylos confertiflora, Lilium humboldti, Jepsonia malvifolia*, Atriplex pacifica, Dendrmecon rigida ssp. harfordii, Dudleya candelabrum, Eriogonum grande var. rubescens, Erysimum ammophilum, Erysimum insulare, Heuchera maxima, Orobanche parishii ssp. brachyloba, Helianthemum greenei, and Lasthenia glabrata ssp. coulteri. These 14 species were chosen for study because they had USFWS candidate status and appeared vulnerable to effects of grazing on Santa Rosa Island (Skinner and Pavlik, 1994). Since 1995 when the study was initiated four of the taxa were federally listed as Endangered. The goals of the study were to survey the current populations of the 14 taxa, determine their known historic and geographic distributions on Santa Rosa and Santa Cruz Islands, document their population sizes and structures, and begin investigation into their reproductive biology. Results from the study indicated that recruitment into existing populations and establishment of new occurrences for the 14 taxa may be limited by, degraded habitat conditions (caused by historic and continued ranching land use), lack of natural or historic anthropogenic disturbances necessary for regeneration, poor vigor of existing plants, current browsing of flowers and fuits, low density of pollinators, and genetic self-incompatibility in small, isolated populations.

In November 1998, the monitoring of *Arctostaphylos confertiflora* and *C. mollis* was expanded to determine what effect, if any, the deer and elk herds on the island were having on these listed plant species.

SANTA ROSA ISLAND MANZANITA

Santa Rosa Island manzanita (*Arctostaphylos confertiflora*) is endemic to Santa Rosa Island (McMinn 1964; Munz and Keck 1963; Munz 1974; Wells 1993) and was initially identified there by Ralph Hoffman in 1934. It is related to *A. tomentosa* ssp. *insulicola* and *A. tomentosa* ssp. *subcordata* which also occur on the Channel Islands and is often confused with these species; but unlike them *A. confertiflora* does not form a basal burl. The lack of this distinctive feature indicates that *A. confertiflora is* probably an obligate seeder and does not resprout after fires.

Investigation of historical records found that *A. confertiflora* was documented in six canyons on Santa Rosa Island (SRI). Subsequent surveys for the 199 study relocated the occurrences in the six canyons and discovered two additional occurrences in two other canyons. *A. confertiflora* was found to exhibit two forms: a low-growing, mounding type (.5 meter high) usually found on exposed ridges; and a tall, erect shrub form, up to 8 feet high, which usually found in sheltered drainage's. The low growing form was by far the most common, being exhibited in more than 95% of the plants mapped during the survey. At this point it is not known whether the low-growing form is genetically determined or whether it is the result of herbivory and exposure to the heavy winds that occur on the island. There are 8 known occurrences of *A. confertiflora* on SRI, ranging in size from 4 individuals to approximately 150. The majority of the occurrences/plants are found northeast of Black Mountain with isolated occurrences near East Point and west of Johnson's Lee at the south end of the island. Investigation of the flowers of A. confertiflora found them to be bisexual, with 10 stamens, one pistil, and a radial, urn-shaped corolla with five fused petals. In the survey few of the plants were documented to have flowers or fruits, and no seedlings or saplings were seen.

Since the introduction of alien herbivores to Santa Rosa Island, most of the island's vegetation, including rare plant species, has been severely impacted by uncontrolled grazing. This has led to fragmentation of populations into small, isolated units, diminished or non-existent reproduction and recruitment, extensive soil loss, and loss of an adequate seed bank and seed bed for regeneration. These factors led to the proposed listing of *A. confertiflora* and 12 other species as Endangered or Threatened by the USFWS in 1995 (formal listing was subsequently completed in 1997). After the proposal for listing was initiated, the National Parks and Conservation Association (NPCA) sued the National Park Service for non-compliance under the Endangered Species Act regarding its management of *A. confertiflora* and *Castilleja mollis*. As part of the eventual court settlement the NPS, Channel Islands National Park, and the Vail and Vickers Ranch, agreed to remove all cattle from Santa Rosa Island. They also agreed to begin additional monitoring of *A. confertiflora* and *Castilleja mollis* to determine the effects of browsing and trampling on them by the remaining deer herds on the island. To assist the Park with this monitoring a scientific panel was convened to develop monitoring protocols and to establish standards to determine the significance of herbivory impacts to *A. confertiflora* and *C. mollis*.

Monitoring of *A. confertiflora* was begun in November 1998 and again in April 1999. This monitoring will continue and its results will determine whether the deer herd is reduced at a faster rate than a previously agreed on schedule. The monitoring basically consists of comparing browsed *A. confertiflora* stems and twigs within and outside of a constructed exclosure. This monitoring is being conducted at two locations on Santa Rosa Island, Telephone Ridge and South Point. Preliminary analysis of the November data indicates that at the South Point site there is significantly more browsing outside the exclosure than inside. However, there was no significant difference identified within and outside the exclosure at the Telephone Ridge site.

SOFT-LEAVED INDIAN PAINTBRUSH

Soft-Leaved Indian paintbrush (*Castilleja mollis*) is a semi-prostrate, woolly, perennial with short, axillary leafy shoots, and stems 20-30 cm long. It is endemic to Santa Rosa Island (there is a purported historical occurrence from San Miguel Island but this may be a misidentification). Previously *C. mollis* was also thought to occur in coastal areas of the mainland by some botanist. However, an examination of *C. mollis* and its distribution concluded that *C. mollis* is confined to Santa Rosa Island and that mainland identifications of *C. mollis* were actually *C. affinis* ssp. *affinis* and *C. affinis* ssp. *affinis* X *C. mollis* (Ingram 1990).

Examination of historical records showed C. mollis to occur at five locations on SRI. Ground surveys in 1994 and 1995 relocated two of the occurrences. One of the occurrences is very large and occurs intermittently along the shore between Jaw Gulch and Sandy Point on the northwest side of the island. Over 1,000 individuals occur at this location in scattered groups of ten to several hundred plants. The other occurrence consists of several hundred plants scattered along the north and northwest facing bluffs of Carrington Point.

C. mollis densities at both occurrences were sampled during the 1994 surveys. Six transects were sampled at Carrington Point and seven at Jaw Gulch/Sandy Point. All C. mollis plants rooted in the belt transect were counted and the number of broken stems was counted on five randomly chosen plants in each plot.

Permanent demography plots (5 X 5 m) were also installed at both locations in 1995. Six were placed at Carrington Point; and three within the Jaw Gulch/Sandy Point occurrence. In 1996 the demography monitoring was expanded to include collection of herbivory data from deer, cattle, and elk.

Table 6. Numbers of plants, flowering, and damage in *C. mollis* plots sampled in 1995, SRI.

Location	# of Plants	% Flowering	% with broken stems
Carrington Pt.			
Plot 1	12	66.7	50.0
Plot 2	48	81.2	29.2
Plot 3	18	83.3	11.1
Plot 4	11	72.7	18.2
Plot 5	16	87.5	6.2
Plot 6	17	64.7	11.8
Jaw Gulch			

Plot 7	30	70.0	16.7
Plot 8	47	59.6	12.8
Plot 9	35	51.4	57.1

Table 7. Numbers of plants, % flowering, % damage, and % mortality data for C. mollis 1996, SRI.

Location & Plot #	# of plants	% flowering	% with broken stems	% dead due to unknown cause	% killed by deer/elk scraping	# of new plants
Carrington Pt.						
Plot 1	16	52.9	47.1	8.3	No data	5
Plot 2	62	52.2	71.6	10.4	No data	19
Plot 3	16	84.2	47.4	16.7	No data	1
Plot 4	14	33.3	60.0	9.1	No data	4
Plot 5	15	50.0	93.8	6.2	No data	0
Plot 6	12	0	47.4	29.4	17.6	3
Jaw Gulch						
Plot 7	13	6.7	36.7	10.0	46.7	0
Plot 8	34	15.7	23.5	21.3	12.8	3
Plot 9	17	2.8	27.8	11.4	45.7	1

Cattle grazing and trampling by deer and elk was documented by Ingram (1990) and others to be impacting *C. mollis* and ungulate trails are common within portions of C. mollis habitat. Several times during the 1995-96 field season cattle, deer, and elk wandered through the C. mollis occurrences that were being sampled. It was the documentation of these ungulate-caused types of impacts which subsequently led to the removal of cattle from Santa Rosa Island; the formation of a scientific panel; and the implementation of additional monitoring of A. confertiflora and C. mollis to determine the effects of deer and elk herbivory on these listed species.

SOUTH COAST SALTBUSH

Atriplex pacifica or south coast saltbush, is a monoecious annual that occurs on all the Channel Islands (except San Miguel Island) as well as on the mainland coast from Los Angeles County south to northern Baja California. It occurs in sandy soils of coastal bluffs in coastal shrubland or coastal strand communities.

Ground surveys for the 1996 study were incomplete due to the inaccessibility of known and potential habitat on SRI and SCI. However, the two known occurrences at Valley Anchorage and Coches Prietos Anchorage on SCI were visited. Absolute number of plants for these occurrences were 28 and 36 respectively. Both occurrences were found on exposed coastal sites with 20-30% vegetative cover. Although evidence of trailing by feral pigs was noted at both sites, damage to the occurrences was insignificant (McEachern, Wilken, and Chess 1997).

CHANNEL ISLAND BUSH POPPY

Dendromecon rigida ssp. Harfordii, or Channel Island bush poppy, is a shrub restricted to Santa Rosa and Santa Cruz islands (McMinn 1964; Munz and Keck 1963; Munz 1974; Junak et al. 1995). It is described as occurring on rocky slopes, canyons, and exposed ridge tops, in association with chaparral and pine-forest communities.

Historical records showed Channel Islands bush poppy to occur at two sites on Santa Rosa Island. These occurrences were found to be extant in 1995 with 3 plants at one site and 5 at the other. Two new occurrences, each containing one plant, were also discovered in previously undocumented locations. Surveys in additional potential habitat failed to find any more individuals of D. rigida ssp. harfordii on SRI.

Historical collections and records showed that Channel Island bush poppy was known to occur at 10 sites on Santa Cruz Island. Seven of the 10 sites were revisited in 1995 (3 locations were inaccessible) and an additional 3 occurrences were discovered during field surveys. Most of the occurrences were found on south to west facing, steep, slopes at elevations between 30 and 420 m.

Occurrence size for the Santa Cruz populations ranged from 1 to 53 individuals. Although some asexual reproduction was evident, no seedlings were found in any of the occurrences.

Flower and fruit production for D. rigida ssp. harfordii were estimated between January and July 1996 at four sites on Santa Cruz Island. Ten plants at each location were tagged and monitored at two-month intervals (January, March, May, and July). During each visit the total number of flowers and fruits were counted on each plant and all fruits greater than 6 cm long were removed. Therefore, any fruits observed during subsequent visits were considered to have been produced during the previous two-month period. The number of seeds per fruit was estimated from a random sample of 20 fruits each in January and July in two of the occurrences.

The number of flowers per plant ranged from 0 to 15 and the mean number of fruits per plant ranged from 0 to 14 over the six-month monitoring period. There was no significant difference in the mean number of flowers or fruits produced between any of the sites but there was a significant difference in flower and fruit production among the sampling periods. Both fruit and flower production were significantly greater in July than in January, March, or May (McEachern, Wilken, and Chess 1997).

To determine self-incompatibility, controlled crossing of *D. rigida ssp. harfordii* flowers was done on three individuals at the Santa Barbara Botanic Garden. Twenty flowers on each plant were hand-pollinated, using pollen from the same flower or flowers on the same plant. To determine cross-compatibility, ten additional flowers were hand-pollinated on each plant, using pollen obtained from different plants. Pollinated flowers were then bagged with nylon mesh to exclude insect visitation. Although there was no significant differences among the plants within each group, there was a difference in the mean number of seeds per fruit in the self-pollinated flowers (0.1 $\pm$ 0.1) and the mean number of seeds in the out-crossed flowers (4.8 $\pm$ 1.0). This suggests that *D. rigida ssp. harfordii* is self-incompatible and that fruit and seed production may depend on occurrence size and the presence of insects actively foraging on its flowers (McEachern, Wilken, and Chess, 1997).

CANDLEHOLDER DUDLEYA

Candleholder dudleya, or *Dudleya candelabrum,* is a succulent, perennial plant and is found on Santa Rosa and Santa Cruz islands (Junak et al, 1995). It has been described as growing in rocky sites, often on north-facing slopes, of coastal bluffs or ridgetops, in association with coastal scrub, chaparral, or pine forest communities (Munz, 1974; Bartel, 1993; Junak et al., 1995).

Prior to the 1995-96 study, *D. candelabrum* was known from three locations on Santa Rosa Island. Two of the locations were on marine terrace outcrops and coastal bluffs, while the third was on a north-facing bluff in the interior of the island. All three occurrences were relocated in 1996 and occurrence sizes were 5, ~ 100, and ~ 500 plants. Two new sites were also located in Tecolote Canyon with approximately 35 and 320 plants each. Since the historic records did not estimate occurrence sizes, population trends could not be determined. Searches in other areas of potential habitat did not find additional occurrences of D. candelabrum.

Surveys on Santa Cruz Island found seven occurrences of D. candelabrum with all but one being new discoveries. There are historic accounts of six other sites but they were inaccessible by land and were not visited. All of the occurrences were found on northeast- to northwest-facing slopes. No seedlings were observed in any of the occurrences but many non-flowering rosettes were generally smaller than those flowering.

A census was taken of the largest occurrence on Santa Rosa Island. All individuals located were tallied as either plants that had flowered in 1996 (flowering stem present); or which showed no evidence of recent flowering. Within those two categories, individuals were then separated into size classes of small, medium, and large. They were then recorded within one of four categories: 1) live, rooted; 2) live, uprooted; 3) dead, rooted; or 4) dead, uprooted. The following table shows the results.

Table 8.

	Flowered			**Did not flower**		
Condition	**Small**	**Medium**	**Large**	**Small**	**Medium**	**Large**
Live, rooted	17	131	50	130	144	3
Live, uprooted	3	11	0	14	2	0
Dead, rooted	0	2	0	24	11	0
Dead, uprooted	2	0	0	6	0	0

Self-compatibility tests were also conducted on D. candelabrum and general observations were noted on pollinators visiting the plants during the course of the survey. Conclusions from the self-compatibility tests and observations indicate d. candelabrum is self-compatible and that insect visitation is required to ensure pollination and seed production (McEachern, Wilken, and Chess; 1997).

RED-FLOWERED BUCKWHEAT

Red-flowered buckwheat or Eriogonum grande var. rubescens occurs on Anacapa, Santa Cruz, Santa Rosa, and San Miguel islands (Munz and Keck 1963; Munz 1974; Junak et al. 1995). Historical records indicated there were seven occurrences on Santa Rosa Island. These occurrences were re-located in 1995-96 and an additional 15 occurrences were also discovered. These 22 populations ranged in size from one plant to more than 1,000 plants scattered over several hectares.

The Santa Rosa occurrences of E. grande var. rubescens were found in two types of habitats. Some occurrences were located on the northern shores of the island in open sites along sandy marine terraces. Other occurrences were located as scattered individuals or clumps of individuals on canyon walls. Individuals from the coastal habitats seemed to have a more compact and decumbent growth form that those growing in the canyons.

On Santa Cruz Island, red-flowered buckwheat was historically known from six locations. Only one of the sites was re-visited and that was found to be extant, however five new occurrences were also discovered in one of the island’s western canyons. Most of the occurrences were composed of both reproductive and vegetative individuals but no seedlings were observed in any of the populations.

During the course of monitoring, several nectar-collecting insects, including small flies and bees, were observed visiting this species.

Controlled crosses were performed on five red-flowered buckwheat plants at the Santa Barbara Botanic Garden. Both self-compatibility and cross-compatibility were tested and after artificial pollination the flowers were covered with nylon mesh to exclude insect visitation. The results indicate that E. grande var. rubescens is self-compatible but that it requires insect visitation for optimum fruit set. Even so monitoring of untested flowers showed that natural fruit set is relatively low and suggests other factors may be limiting fruit production.

COAST WALLFLOWER

This suffrutescent, perennial herb is found only on Santa Rosa Island and at Monterey Bay (Munz and Keck 1963; Munz 1974; Price 1993). It grows in coast sand dunes in association with coastal strand communities. At the time of the 1995-96 study there were no historical records for Erysimum ammophilum on Santa Rosa Island. All of the potential habitat was identified and searched though and two small occurrences of 6-8 plants each were discovered. At the time of the discovery (late April), plants in both Santa Rosa Island occurrences were blooming and forming fruits.

ISLAND WALLFLOWER

This relative of coast wallflower grows on Anacapa, Santa Cruz, Santa Rosa, and San Miguel islands (Munz and Keck 1963; Munz 1974; Junak el al. 1995). On these islands it can found on coastal cliffs and rocky slopes in chaparral and coastal scrub communities. Erysimum insulare ssp. insulare was purportedly collected on Santa Rosa Island in 1930, 1939, and 1941 but additional taxonomic work showed the collected specimens to be either E. capitatum or E. suffrutescens. A positive collection of E. insulare ssp. insulare was subsequently made at Skunk Point in 1991 but surveys in 1994 and 1995 failed to relocate the occurrence. All other additional potential habitat was also surveyed in 1994 and 1995 and three occurrences were discovered on steep, sandy, north- to northeast-facing bluffs, in coastal bluff scrub vegetation. Two of the occurrences consisted of only about 20 plants each but the third contained more that 100 individuals. Plant density data for the largest Santa Rosa occurrence was collected in 1994 and again in 1996.

There is one historical record of E. insulare ssp. insulare from Santa Cruz Island. This site was not physically accessible in 1996 but observations of a portion of the site using binoculars, failed to find any plants that could be identified as E. insulare ssp. insulare.

In May 1996, the largest occurrence of E. insulare ssp insulare was sampled to determine plant density and flowering and fruiting characteristics. The area inhabited by the plants is roughly 210 X 40 m, on a north-facing slope. All plants rooted within five randomly placed 5 X 20 m transects were counted. For each plant, crown length and width were measured. For two randomly chosen plants per transect, stem diameter at ground level and number of inflorescences were measured and counted. Three inflorescences were then randomly chosen and the number of fruits, flowers, and seeds were then counted (see Table **). Mean density was calculated for the population, flowering and fruiting data were summarized, and crown area and stem diameter were averaged for the site. Regression analyses were then performed to determine whether stem diameter or crown area could be used as a field measure to predict the number of inflorescences per plant. Regression analyses were also used to determine whether stem diameter, crown area or numbers of inflorescences were reliable predictors of numbers of flowers per inflorescence.

Regression analysis results indicated that only crown area was a good predicator for the number of inflorescences per plant.

Table 9

Parameters	Mean ± SD	Median	Range
Density: live plants	43.2 ± 23.32	30	23 - 77
Density: dead plants	1.8 ± 1.3	2	0 - 3
Crown - Area	1455.29 ± 2424.67	515.50	12 – 15,616
# of Inflorescences	39.40 ± 56.68	14.00	3 – 178
Fruits/Inflorescence	18.57 ± 7.57	18.5	3 - 34

ISLAND RUSH-ROSE

At the time of the 1995-96 study, Helianthemum greennei or island rush-rose was described in the literature as occurring on Santa Catalina, Santa Cruz, Santa Rosa, and San Miguel islands (McMinn 1964; Munz and Keck 1963; Munz 1974; Junak et al. 1995). 14 occurrences were subsequently re-located on Santa Cruz Island but attempts to re-locate any occurrences on Santa Rosa Island were at that time unsuccessful. In April 1999 however, two individuals of H. greenei was re-discovered on the west end of Santa Rosa Island within a recently constructed deer/elk exclosure (Chaney, personal communication).

The 14 occurrences on Santa Cruz Island ranged from 3 to 1000+ plants and occurrence size was apparently related to recent fire history. Four of the 14 occurrences had been burned in 1994 and their mean population size was 663 ± 208. Mean population size in the ten unburned occurrences, however, was 9 ± 3. Most of the occurrences were found on flat to moderate, north-facing slopes in rocky soils. No seedlings were observed in any of the occurrences even those that had recently burned.

General observations suggest H. greenei prefers open sites. Even in the unburned habitat where vegetation cover exceeded 60%, most island rush-rose plants were found growing in the small, open sites among the dominant vegetation. Flowers of H. greenei were also observed to be visited by small flies and nectar- and pollen-gathering bees.

The reproductive biology of H. greenei was evaluated by estimating the number of flowers per plant in six populations on Santa Cruz Island (see Table **). This assessment was done in April. In May, random samples of 20 fruits per occurrence were used to evaluate the number of seeds per fruit.

Table 10.

Location	Mean # of Flowers
Cebada	100.3 ± 8.7
Centinela 1	97.5 ± 4.5
Centinela 2	112.2 ± 14.7
China 1	57.8 ± 7.2
China 2	53.1 ± 7.6
China 3	50.5 ± 7.8

Self-compatibility tests for island rush-rose were conducted on three plants at the Santa Barbara Botanic Garden. Self-compatibility was estimated by pollinating 10 flowers on each plant, using pollen from the same flower or flowers on the same plant. Ten additional flowers on each plant were then covered with nylon mesh bags to exclude pollinators and estimate self-pollination.

No significant differences were found among plants for with self-pollination or unmanipulated flowers. The overall mean number of seeds per fruit derived from the manipulated flowers was 11.2 ± 0.2. The overall mean number of seeds per fruit from the unmanipulated flowers was 4.6 ± 0.7. These numbers suggest that while H. greenei is self-compatible and that seed set can occur in the absence of pollinators, insect pollination may enhance seed set under natural conditions.

ISLAND ALUMROOT

Heuchera maxima, or island alumroot, is a perennial plant found only on Anacapa, Santa Cruz, and Santa Rosa islands. It is found growing on coastal bluffs, shaded north-facing slopes, and canyon walls in coastal scrub, oak woodland, pine forest, and riparian vegetation communities (Munz 1974; Elvander 1993; Junak et al. 1995).

In historical records, H. maxima was known to occur in four canyons on Santa Rosa Island. Three of the four sites were relocated in 1996 and occurrence size ranged from 1 to 150+ individuals. On Santa Cruz Island, H. maxima was historically recorded from 16 sites. Seven of the sites were relocated in 1996 but the remainder were inaccessible and were not surveyed. The Santa Cruz occurrences ranged in size from 15 to more than 170 plants. On both islands most of the occurrences contained a complete range of plant sizes, from seedlings to flowering and fruiting individuals.

Reproductive success was evaluated by estimating the number of seeds per flower in three populations on Santa Cruz Island and three sites on Santa Rosa Island. Seeds were counted in each of 20 randomly sampled fruits. Significant differences were found in the number of seeds per fruit at each of the locations.

Table 11.

Location	Mean # of Flowers
Pelican (SCI)	29.5 ± 2.2
Tinkers (SCI)	33.5 ± 1.6
Stanton (SCI)	23.7 ± 2.1
Lobo 1 (SRI)	31.7 ± 2.1
Lobo 2 (SRI)	25.3 ± 2.0
Lobo 3 (SRI)	28.8 ± 0.8

Studies were conducted on self-compatibility, pollinator dependency, and natural pollination at the Santa Barbara Botanic Garden. Results of the tests suggest that H. maxima is self-compatible, but that low seed set (7.3 per flower) in the pollinator dependency test indicates H. maxima is dependent on insect pollination for maximum seed production.

ISLAND JEPSONIA

Jepsonia malvifolia or island jepsonia is a perennial plant that is found on Guadalupe Island (Baja California), the southern Channel Islands, Santa Rosa Island, and Santa Cruz Island. It is found growing on coastal bluffs and north-facing slopes in chaparral, coastal scrub, oak woodland, and pine forest. What is unique about island jepsonia is that it flowers during the fall and winter months and then develops leaves during the winter and spring.

On Santa Rosa Island, *J. malvifolia* was historically known from three main locations: Becher’s Bay, Black Mountain, and South Point. These sites were resurveyed during the winter of 1995-96, when the plants were flowering. In the Becher’s Bay area, *J. malvifolia* was found growing in patches on north-facing slopes. It occurred in small grassy openings in Torrey Pine and chamise chaparral. It was not present in eroded areas where bedrock is exposed or where the soil lichen was no longer intact. *J. malvifolia* was also absent in areas where vegetation cover exceeds 80% or where grass litter had accumulated in a thick thatch.

The *J. malvifolia* plants in the Black Mountain area were much more clumped with distances of 100’s of meters between the groups of plants. Nine groups of plants were found and they ranged in size from 5 to 106 plants. Again, *J. malvifolia* was absent in severely eroded soils. Presence of *J. malvifolia* was even more sparse in the South Point area. Seven occurrences were found there and they ranged in size from 8 to 19 plants.

On Santa Cruz Island, J. malvifolia was historically known from 12 locations prior to 1995. Eight of those sites were relocated in 1995 but the remaining four were not due to accessibility constraints. The eight relocated occurrences ranged in size from 13 to 53+ individuals.

SANTA CRUZ ISLAND MALOCOTHRIX

Santa Cruz Island Malocothrix is a 20 – 30 cm tall annual in the sunflower family. It only occurs on Santa Cruz Island, Santa Rosa Island, and San Miguel Island. It grows in coastal bluffs, coastal flats, and coastal sage scrub habitats.